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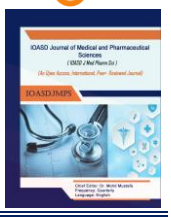

Comprehensive Safety Strategies in Radiation and Magnetic Field Areas

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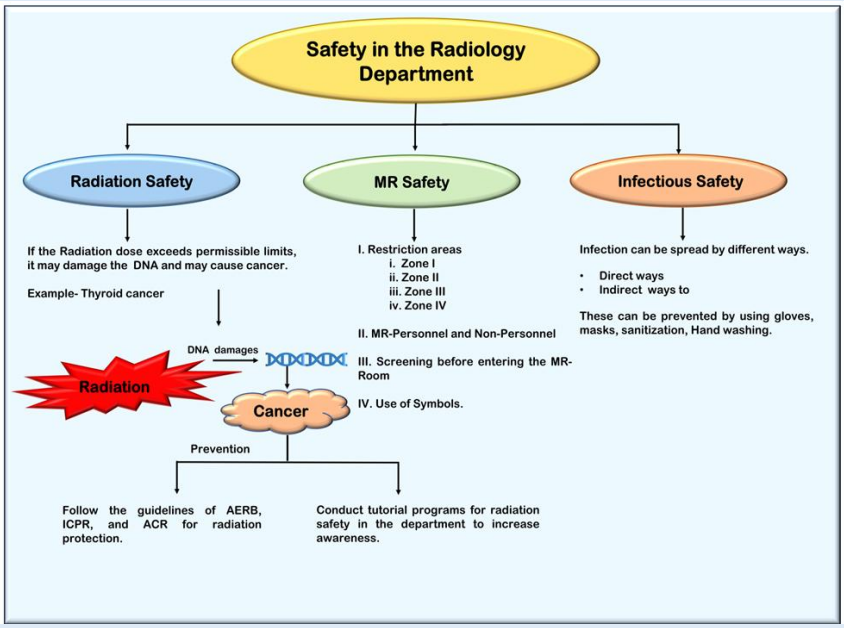
ABSTRACT

Review Article

GRAPHICAL ABSTRACT


Safety in the Radiology Department
Radiation Safety
MR Safety
Infectious Safety
If the Radiation dose exceeds permissible limits, it may damage the DNA and may cause cancer.
Example- Thyroid cancer
DNA damages
Radiation
Cancer
I. Restriction areas
i. Zone I
ii. Zone II
iii. Zone III
iv. Zone IV
II. MR-Personnel and Non-Personnel
III. Screening before entering the MR-Room
IV. Use of Symbols.
Infection can be spread by different ways.
Direct ways
Indirect ways to
These can be prevented by using gloves, masks, sanitization, Hand washing.
Prevention
Follow the guidelines of AERB, ICPR, and ACR for radiation protection.
Conduct tutorial programs for radiation safety in the department to increase awareness.

The discussion concerns radiation safety and its absorbed limits for workers who operate in radiation-prone situations and for patients. Low radiation doses are experienced by healthcare personnel who work in radiation-prone areas. The thyroid is the organ that is most impacted by this exposure. Thyroid stimulating hormone levels and radiation exposure over five years are significantly correlated. Radiation exposure can harm DNA and affect the DNA repair system. The healing process may be slowed down by radiation exposure received during diagnosis or therapy. Health professionals operating in radiation-prone areas should use a variety of protective techniques to either avoid or experience fewer health issues. Radiation plays a crucial role in patient diagnosis and treatment, which is why the As Low as Reasonably Achievable (ALARA) principle was implemented in federal regulations. This principle is designed to ensure that all necessary precautions are taken to reduce radiation exposure to the minimum level possible. ALARA means avoiding unnecessary radiation exposure followed by three basic protective measures: time, distance, and shielding. Atomic Energy Regulatory Board (AERB) governs nuclear and radiation facilities and operations to make sure that using nuclear energy and ionizing radiation in India does not cause an excessive risk to public health and the environment. International Commission on Radiological Protection (ICRP) recommended dose limits for workers, trainees, and the general public. Dose limits help to ensure that no person is exposed to an excessive amount of radiation in normal, planned situations. On the other hand,

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Magnetic Resonance (MR) safety is also very important in radiology departments or centers, American College of Radiology (ACR) recommended the MR sites should be divided into four zones and Microorganisms that can be transmitted by radiology procedures. Radiographers need to have adequate knowledge and practices of infection control.
Keywords: Radiation, ICRP, AERB, ACR, MR safety strategies.

1. INTRODUCTION

Patients, doctors, and employees in a variety of disciplines, such as radiology, interventional cardiology, and surgery, are concerned about radiation safety (Frane & Bitterman, 2024). Employees in the radiology department are vulnerable to a range of risks, including radiation exposure, needle prick injuries sustained during investigations, lead aprons that expose physiological fluids, muscle strain from wearing heavy lead aprons, and strain from carrying portable test equipment (Dabhekar & Naik, 2021). Radiation protection attempts to prevent excessive radiation exposure to minimize the harmful effects of ionizing radiation. The Atomic Energy Regulatory Board (AERB) is the national authority for ensuring that the use of ionizing radiation and nuclear energy does not cause any undue risk to the health of workers, members of the public, or the environment (Mohapatra, 2024). AERB is provided with the necessary powers and mandate to frame safety policies and lay down safety standards and requirements for monitoring and enforcing the safety provisions (Singh et al., 2017). As Low As Reasonably Achievable (ALARA) has been applied to the workplace and to protect the public (Lips, 2021). In routine non-emergency situations, the goals are to minimize small incremental exposures daily or per specific task, and every year, to keep the total annual dose equivalent as far below regulatory limits as practical (Do, 2016). Radiation safety officers (RSOs) ensure that strategies to prevent and eliminate such hazardous activities are conducted regularly. To protect patients, radiologists, and medical personnel, safety supervision in radiology is crucial (*The Role of the Radiation Safety Officer in Patient Safety | IntechOpen*, n.d.). Magnetic Resonance Imaging (MRI) has developed into a comparatively safe, non-invasive diagnostic technique. Although there aren't any long-term hazards linked to radiation exposure, there are a few short-term risks with MRI. These risks include incompatible implanted devices, tissue heating from radiofrequency pulses, peripheral nerve stimulation from magnetic field gradients, and magnetic objects that could become projectiles if they are accidentally brought into the scanning room (Shah & Aran, n.d.). By implementing a strict MR imaging safety policy that includes staff training, patient and staff screening, strict access management to the MR imaging environment, and close attention to scan parameters that impact RF hearing and nerve stimulation, such risks can be reduced (Ohliger et al., 2020). Specific policies and safety procedures are required to ensure safety in the MR environment. The four zones of an MR site allow MR personnel to monitor and restrict the area closely (Sammet, 2016). Infection prevention and control (IPC) practices are key to preventing and controlling the spread of pathogens in medical imaging departments. This review's primary and crucial components are the observational safety audits and routine staff safety inspections in the radiology department (Jimenez & Lewis, 2023).

2. BASIS OF RADIATION SAFETY

Health is our most important concern in every field and the part played by the healthcare worker in the medical field is remarkable. Safety requires much attention to the work (Thimbleby, 2013). Safety is necessary for both patients and as well as for healthcare workers but in the current scenario, People are not taking this seriously in many areas. Few efforts should be made to improve employee protection (Chau, 2024). The Radiology department can fund and support an agenda for the safety of workers, doctors, patients, and accident prevention by implementing comprehensive study programs that will increase their knowledge and minimize the risk of accidents (Ploussi & Efstathopoulos, 2016). All healthcare workers in the radiology department will be much safer if regular education and training programs are provided about workplace ecological risks and their costs. Policies and regulations about ecological protection are followed, and a culture of observation, reporting, and quick action is encouraged (Siewert et al., 2013).

3. ATOMIC ENERGY REGULATORY BOARD (AERB) AND RADIATION PROTECTION

AERB is an Indian regulatory board for the radiology protection appraisal and regulation of such services using ionizing emissions in India. The atom fission synchronizes nuclear protection is a nuclear reaction or produced by a nuclear reaction (Kumar et al., 2017). The Board aims to make sure such like the utility of collisional emission and reaction here is not reason excessively difficult or hazardous to the well-being of the surroundings (Thilagam et al., 2021). The field of radiology is speedily rising with the assistance of technological advances and the internationalization of healthcare. These ongoing advancements have a significant impact on the quality of treatment and service delivery (Wareing et al., 2017). To improve patient safety and care values, physicians and expert organizations should show how to effectively plan, handle, and attempt difficult situations. Above all, the medical facility providing radiology services wants to foster progress and practical steps that are essential in advanced radiology (European Society of Radiology (ESR) & European Federation of Radiographer Societies (EFRS), 2019). Safety administration in radiology is necessary for protecting the patients, radiologists, and medical

associations (i.e., protecting the organization's assets and its status with patients) (Craciun et al., 2015a). Faculty tutoring programs about the environmental risks and their cost at the place of work, fulfilments with standards instruction on radiation protection and security of the environment, and progression of a traditional observation, announcing and communicating, and taking accomplishment, all these things take time in the direction of improving general protection for every health employee in this field (Rodrigues et al., 2024).

In the radiology department, radiation exposure, a prick of a needle, and workplace efficiency trauma are the general things of reviewing for trauma, and the bulk of the radio diagnosing section has distinct strategies for reducing or obstructing their circumstance (Flug et al., 2018). Ionizing radiation is harmful to the human body. There are several medical residents, radiology technologists, radiology assistants, and nurses working in the radiology department, which are directly or indirectly revealed with radiation exposure (Akram & Chowdhury, 2024). The number of radiological scans is directly proportional to working employees. Several radiologic scans require more radiation such as high-resolution computed tomography, which directly affects patients, radiology technologists, and nurses working in the scanning area (Shbeer, 2024). The chief risks for employees and healthcare professionals operational in the Department of Medical Radiology and tried to explain the main component of the staff safety program to make strategies to avoid and reduce these risks (Craciun et al., 2015b).

Employees need to be familiar with the risky equipment, apparatus, or appliances attending their work by which they can exposed and what must be done to keep away from hurts or sickness during these procedures below the working Health and Safety Act 2004, employees have a compulsion to report any hazards recognized in the place of work (Messano et al., 2014). Management assurance of medical fitness and risk-free and strong staff involvement are very important factors in any place of work medical fitness and risk-free program. An act has advised maximum permissible doses, particularly in various cities, and recognized physical codes by setting specific calculating values equivalent to hazardous free from radiation profession (Hung et al., n.d.). The smaller dose is also poisonous to the body. To avoid the smaller radiation, many programs are ongoing and concerned about this (Shi et al., 2022). Many authors and concerned persons planned that it should be taken into account that there should be protection for employees against X-rays and not receive too much radiation. Protection of employees from radiation, lead aprons, or lead screens must be available in the x-ray room (Yıldız et al., 2022). Medical students, staff, nursing persons, and technicians should also wear a lead apron and have their care, and protection**.** One encouraging factor is that there are many ways of organizing the provision of medical care to individuals or a community radiation security enhancement (Heo et al., 2016). An extremely good primary and prior footsteps need to be taken so that everyone who works or employs, staff medical professionals should take a safety course. Training can help and result in the development of safer use of radiation (Allam et al., 2024). It is also significant to encourage adequate communication amongst the healthcare team and ensure that everyone understands the importance of radiation safety and that it is his or her work. Medical attendants and technologists must make urges to speak out if they are worried about safety operations ("Optimisation of Radiological Protection in Digital Radiology Techniques for Medical Imaging," 2023). Radiologists or Physicians should be made to realize that the staff working and supporting them needs to raise their voices over the issue and that they need to be considered for those concerns and be worried about them. The supreme importance of dose reduction is also considered, the reason that radiation exposure due to patients our healthcare workers get exposed a lot (Knechtges & Carlos, 2007). Calculating patient dose, accordingly, helps employees at the same as patients. That includes minimizing fluoroscopy time as well as the number of fluoroscopic images ("Radiation Doses to Staff in a Hybrid Operating Room," 2020). Patients, physicians, and staff members in a variety of disciplines, such as radiology, interventional radiology, cardiology, and surgery, may be affected by radiation. The optimal radiation dosage for healthcare workers is dependent on the amount of radiation released during fluoroscopic investigations (Miller et al., 2010). The cumulative dose exposures of healthcare organizations are somewhat mitigated by radiation from diagnostic imaging machines such as computed tomography (CT), mammography, and Positron Emission Tomography (PET) scans although, any radiation exposure causes a possible risk to both patients as well as medical staff similarly (Hussain et al., 2022). Radiation shelters' purpose is to scale back avoidable exposure to radiation with a target to attenuate the damaging effects of radiation.

Within the hospital especially in the radiology department, the utilization of radiation has become an unavoidable equipment used for the medical diagnosis and clinical treatment of a spread of medical situations (Chida, 2022). Most radiation dose exposures in radiological environments originate from fluoroscopic procedures, which use computed radiography to acquire impulsive and cinematic functional imaging. Especially, radiologist or health worker staff that use fluoroscopic imaging procedures external to committed radio diagnosis or interventional radiology departments have low attachment to the radiation protection program (K. P. Kim et al., 2012). Numerous departmental operations use fluoroscopy, including those in the fields of orthopedics, urology, interventional radiology, interventional cardiology, vascular surgery, and gastrointestinal. Radiation exposure danger perception and dosage reduction strategies will become increasingly important

as radiation exposure spreads. Consideration involves an understanding of the advantages and risks of using radiation dosage for radiological procedures or clinical treatments (De Mauri et al., 2017). Frequently, investigations that expose patients to comparatively maximum doses of radiation-such as procedures in interventional Radiology and interventional cardiology are medically necessary, and thus the advantages are more important than the hazard (Mohammadi et al., 2017). While acknowledging that radiation is an essential component of patient diagnosis and treatment, the ALARA principle was developed to ensure that all steps to reduce radiation exposure are taken. ALARA is defined by the codification of authorities' rules and regulations (S. O. Hansson, 2013). Radiation exposure of any kind will raise the risk of uncontrollable effects, namely the likelihood of acquiring cancer after radiation exposure, and warning symbols used in radiation-prone areas shown in Fig 1 (Choi & Choi, 2021).

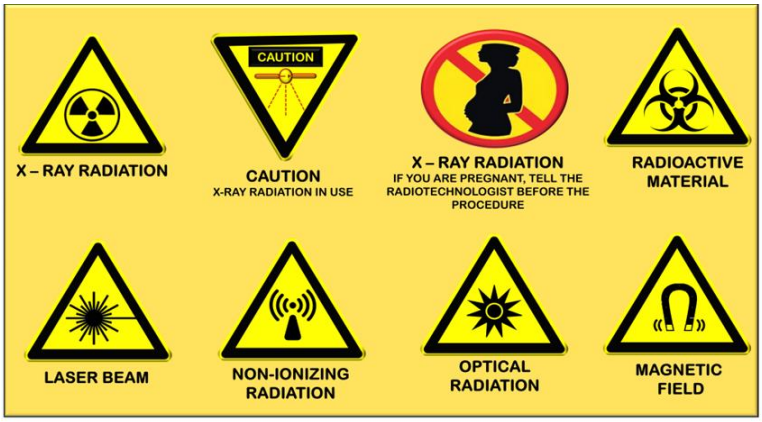

Figure 1: This figure depicts internationally recognized symbols used to indicate radiation-prone areas. These symbols serve as critical safety warnings, alerting individuals to the presence of ionizing radiation and the need for protective measures in such zones.

4. EFFECTS AND DOSES OF IONIZING RADIATION

When assessing the various methods for safeguarding patients and medical personnel, it is essential to have a basic understanding of the science underlying radiation's harmful effects. High-energy photons from the electromagnetic spectrum make up X-rays (Kesavachandran et al., 2013). Compared to lower-energy photons, X-rays are remarkable because they can ionize atoms and destroy chemical bonds. Free radicals are chemically active substances produced by this ionization that have the potential to indirectly harm DNA (Borrego-Soto et al., 2015). Both direct exposure to the X-ray beam and dispersed X-rays can expose patients and medical workers to X-ray radiation. The energy that is deposited in tissues by scattered X-rays is less than that which is deposited straight from the X-ray source because scattered X-rays lose some of their energy during the scattering process (Akram & Chowdhury, 2024; Wakeford, 2009)

4.1 Radiation doses can be expressed in three different ways

4.1.1 Absorbed dose (D)

The amount of radiation energy that is deposited in a tissue or per mass unit. The conventional unit of absorbed dose is rad, with 1 rad = 100 ergs of energy deposited in 1 gram = 0.01 joules of energy/kg in any irradiated medium (Fisher & Fahey, 2017a). The gray (Gy) is the SI unit, which is equal to 100 rad or 1 J/kg. The term "absorbed dose" is most commonly used when considering radiation therapy (Allisy-Roberts & Williams, 2008).

4.1.2 Equivalent dose (H_T)

The equivalent dose (H_T), is determined by multiplying the absorbed dose by the organ or tissue (D_T) and the radiation weighting factor (WR). It is the average absorbed dose over a tissue or organ. This factor is dependent on the type and energy of the incident radiation (*Specific Absorbed Fractions for Reference Paediatric Individuals - , ICRP PUBLICATION 155, ICRP PUBLICATION 155, 2023*, n.d.). H_T is measured using the sievert or millisieverts (mSv) but rem is still commonly used (1 Sv = 100 rem). In quantitative terms, the equivalent dose is less fundamental than the absorbed dose, but it is more biologically significant (Ferrari et al., 2023).

$$H_T = W_R \times D_T$$

Where:
H_T - is the equivalent dose in sieverts (Sv) absorbed by tissue T,
D_T - is the absorbed dose in grays (Gy) in tissue
W_R - is the radiation weighting factor defined by regulation.

4.1.3 Effective dose

It is the tissue-weighted sum of the equivalent doses in all specified tissues and organs of the human body. Effective dose is a mathematical concept used in

radiation protection as the basis for calculating annual radiation limits to workers and members of the public from exposure to radiation and intakes of radionuclides (Fisher & Fahey, 2017b). It has the same unit as J/kg with the special name sievert (Sv). Effective dose is also used for comparing an assigned occupational dose of record to radiation protection standards. Thus, an effective dose is not a real radiation dose to a person but rather is a computed number representing an approximate measure of stochastic risk (Osei & Darko, 2013). A comprehensive dosage is calculated for the entire body. It involves adding equivalent dosages to each organ, taking into consideration that organ's unique radiation sensitivity. An understanding of these definitions is critical to interpreting dose recommendations (Povinec et al., 2013). ICRP recommended dose limits are mentioned in **Table 1** (Clement et al., 2021).

Table 1: The dosage limits suggested by the International Commission on Radiological Protection (ICRP) are summed up in this Table.

Types of Dose Limit	Dose limit for Occupational Exposure (Employees)	Trainees under the age of 18	Dose Limit for Public Exposure
Effective Dose	20 mSv/year, averaged over a defined five-year period, with no single year exceeding 50mSv	6 mSv/year	1 mSv/year
Effective Dose	Once the employee declares pregnancy, the dose to embryo /fetus should not exceed 1mSv during the remainder of the pregnancy	-	-
Equivalent Dose: Lens of the Eye	20 mSv/year, averaged over defined five-year periods, with no single year exceeding 50 mSv	15 mSv/year	15 mSv/year
Equivalent Dose: Skin	500 mSv/year	150 mSv/year	15 mSv/year
Equivalent Dose: Hands and Feet	500 mSv/year	150 mSv/year	-

5. WAYS FOR RADIATION PROTECTION

Time, Distance, and Shielding are the three factors that determine radiation exposure. Reduced exposure time, increased separation from the source, and the use of suitable shielding are all required for protection as shown in Fig 2 (J. H. Kim, 2018).

5.1. To reduce the time of exposure

The amount of radiation a worker receives is directly correlated with how long they are exposed to a source of radiation. The dosage is directly impacted by how long a person spends at the source; shorter the stay, the dose will be lower received by a person (*The Radiation Safety Education and the Pain Physicians' Efforts to Reduce Radiation Exposure*, n.d.). In C-arm fluoroscopy-guided interventions, the time spent checking the C-arm fluoroscopy is related to the radiation exposure. The longer the exposure time, the more radiation exposure to the doctor (Chang et al., 2014). As a result, cutting down on C-arm fluoroscopy usage duration is crucial. To decrease usage time, the radiographer must verify the X-ray at the office and the doctor must enhance his intervention skills (Cho et al., 2011).

5.2. Maintain distance

Radiation exposure can be decreased by increasing the distance from the radiation source. The amount of radiation exposure is inversely proportional to the square of the distance. Accordingly, the radiation dose can be lowered to 1/4 by doubling the distance from the radiation source (Tam et al., 2023). As a result, keeping a greater distance from the X-ray source is a highly effective radiation protection measure. Two steps behind the mobile support structure can reduce the radiographer's exposure by roughly 80%, according to a prior study of radiographers. According to another study, radiation exposure can be reduced by almost 73% by moving just 20 cm away from the center of the X-ray field (J. H. Kim, 2018). Increasing the distance between you and the radiation source wherever it makes sense (for example, by using a sealed source) will reduce the radiation exposure (Jaafar Ghalib Jabbar Lftta & Ali Hadi Kazem Nasser, 2024).

5.3. Use shielding appropriately

This includes radiation shields, automatic interlock systems, and radiation monitoring devices. To ensure radiation safety during C-arm fluoroscopy-guided procedures, a variety of shielding equipment is available, including radiation-reducing gloves, aprons, thyroid protectors, lead glasses, and caps (Ryu et al., 2013). No use of the devices cannot shield the doctor and radiographer from radiation. More than 80 percent of pain doctors in Korea wear an apron and thyroid protector. However, less than 35% of people used radiation-reducing gloves, and over 40% of people used lead glasses (Cheon et al., 2018). The cost of radiation shielding equipment is high, and using them can be uncomfortable. Aside from lead or lead equivalent aprons, protective curtains, and temporary or movable shields, this kind of control is typically integrated into

the building itself, such as the concrete walls next to a radiation oncology accelerator (Lakhwani et al., 2019). Observe the instructions provided by the competent authority and vendor when utilizing portable X-ray equipment (Makdissi et al., 2016).

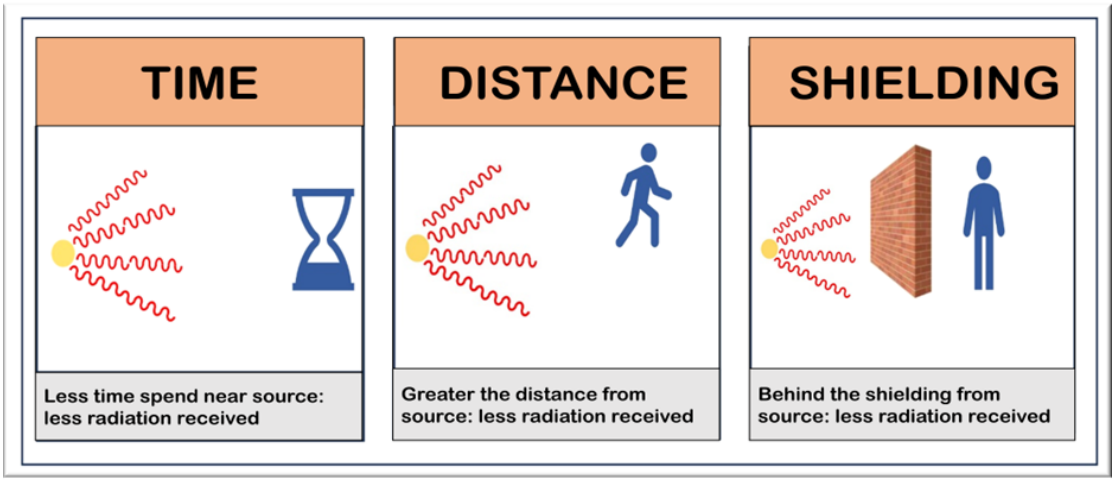
TIME
DISTANCE
SHIELDING
Less time spend near source: less radiation received
Greater the distance from source: less radiation received
Behind the shielding from source: less radiation received

Figure- 2: Radiation Protection Principles: The three main tenets of radiation protection are depicted in this figure, utilizing the right shielding materials to block or attenuate radiation, increasing distance from the radiation source to reduce intensity, and reducing exposure time to reduce dose. When combined, these tactics guarantee efficient safety precautions in radiological settings.

6. MR SAFETY STANDARDS

There are not any recognized hazards at the moment, magnetic resonance might have bioeffects. It is crucial to properly follow safety precautions because failing to do so could lead to possibly life-threatening situations (Mittendorff et al., 2022). The possible bioeffects of magnetic resonance imaging (MR) should be discussed with the readers, along with the precautions that need to be taken to avoid any negative results. These safety precautions were developed based on suggestions from the "American College of Radiology White Paper on MR Safety" (Maram Khaled Altelaihi & Haifa Ali Algarni, 2024).

6.1. MR Bioeffects

The experience of biological effects differs between individuals regarding the frequency of experience, the strength of the experienced effect, and individual perception of discomfort (B. Hansson & Björkman-Burtscher, 2023). Apart from differences in individual predisposition, a variety of circumstances related to the scanner, the examination, and patient care will further influence the experience of bioeffects. Patients undergoing MR examination are exposed to three different forms of electromagnetic fields (Hartwig et al., 2009).

6.1.1. Static magnetic field

Static Magnetic Fields (SMF) are supposed to interact with the living matter and cause changes in its properties (Zhang et al., 2023). The effects of magnetism on biological systems have long been of interest to the scientific and non-scientific communities for their applicability in diverse fields, which can cover since cancer treatment (Ghodbane et al., 2013). It can raise the skin temperature. It can cause electrical induction and cardiac effects with elevation of T-wave are not proved to be hazardous at field strength <3 Tesla. Scanning at amplitude. It also has potential effects on neurons (Gupta et al., 2008). All these bioeffects field strength >2 Tesla may cause vertigo, headache peripheral epileptogenic potentials, visual flashes, and also has thermal effects (Khan et al., 2022).

6.1.2. Gradient field-related

Gradient coils are used to generate the spatially varying gradient magnetic fields used to phase- and frequency-modulate the nuclear magnetic resonance (NMR) signal and enable position encoding in MRI (Winkler et al., 2018). The possible effects include ventricular fibrillation, epileptogenic potentials, and visual flashes. It also has thermal effects. All these effects have not been significant in presently used clinical MR systems (Ladd et al., 2018). The gradient system is divided into several subsystems: the gradient coil (GC), the gradient driver or power amplifier (GPA), and the interconnecting parts such as cables, filters, connectors, etc. Also considered a part of the gradient system are shim coils and passive shims when they are built into the GC (Gudino & Littin, 2023).

6.1.3. RF magnetic field

Radiofrequency (RF) coils are an essential MRI hardware component. They directly impact the spatial and temporal resolution, sensitivity, and uniformity in MRI. Advances in RF hardware have resulted in a variety of designs optimized for specific clinical applications (Gruber et al., 2018). RF coils are the “antennas” of the MRI system and have two functions: first, to excite the magnetization by broadcasting the RF power (Tx-Coil)

and second to receive the signal from the excited spins (Rx-Coil) (Kwok, 2022). Transmit RF Coils emit magnetic field pulses to rotate the net magnetization away from its alignment with the main magnetic field (B_0), resulting in a transverse precessing magnetization. It can result in energy deposition and tissue heating. Specific Absorption Rate (SAR) is the measure of tissue energy deposition and its unit is Watt/Kg. FDA limit for clinical examination is SAR<0.4 W/Kg (Panagopoulos et al., 2013). However, experiments saw no clinically hazardous effects or increased skin and body temperature with SAR up to 4W/Kg. SAR increases with increasing field strength. There is a four-fold increase in SAR at 3T as compared to 1.5 T (Wang et al., 2007). Testes and eyes are more temperature-sensitive organs. Table 2 shows the categorization employed for implants and medical devices labeled as MR Safe, MR Unsafe, and MR Conditional medical in an MRI environment, as established by the American Society for Testing and Materials (ASTM) (Shah & Aran, n.d.).

Table 2: Understanding MRI Safety Labeling.

	MR Safe Items pose no safety hazards in the MR environment. They may be placed anywhere in the MR environment. Encompasses all items that are non- conductive, non-metallic and non-magnetic.
	MR Conditional Items may safely enter the MRI scanner room and has been proven to not pose identified risks when used specific conditions within a defined MRI setting. MR conditional items come with labels that outline any potential limitations within the MRI environment.
	MR Unsafe Items should not enter the MR environment. Patients with MR Unsafe devices should not be scanned. MR Unsafe items encompass magnetic objects like a pair of ferromagnetic scissors.

6.2. MR Safety Issues

6.2.1. Restrictions on site access

According to the ACR white paper, the MR site should be split into four zones to prevent non-MR personnel from entering freely (Sammet, 2016). Zone I: This includes all areas that are freely accessible to the general public. This area is typically outside of the MR environment itself and is the area through which patients, health care personnel, and other employees of the MR site access the MR environment (Cross et al., 2018). Zone II: This area is the interface between the publicly accessible uncontrolled Zone I and the strictly controlled Zone III and IV. Zone II is for preparation and patient history; Only MR Personnel will be able to supervise patient movement in Zone II. Patients are greeted in Zone II and are not free to move throughout Zone II but are rather under the supervision of MR Personnel (Tsai et al., 2015). It is in Zone II that the answers to MR screening questions, patient histories, medical insurance questions, etc., are typically obtained. Zone III regions should be physically restricted from general public access-for example, by key locks, pass-key locking systems, or any other reliable restricting method that can differentiate between MR Personnel and non–MR Personnel (Safety et al., 2013). Only MR Personnel shall be provided with free access, such as access keys/passkeys, to Zone III regions. Zone IV: This area is synonymous with the MR scanner magnet room itself—i.e., the physical confines of the room within which the MR scanner itself is located. Zone IV, by definition, will always be located within Zone III as it is the MR magnet and its associated magnetic field that generates the existence of Zone III itself (Weidman et al., 2015). Zone IV regions should also be marked and demarcated as being potentially hazardous due to the presence of very strong magnetic fields. As part of the Zone IV site restriction, all MR installations should be installed in such a way as to provide for direct visual observation by Level II MR Personnel to access pathways into Zone IV regions. Zones III and IV are off-limits to non-MR personnel without previous screening (Thomas & Peter, 2022).

6.2.2. MR Personnel/Non-MR Personnel

MR Personnel are those who have been trained and educated about MR safety and approved by the MR Medical Director of the institution. Level 1 MR Personnel have education about their safety while level 2 MR Personnel are trained in broader MR safety issues. There are two levels of MR Personnel [8, 84]. Level One MR Personnel-those who have passed minimal safety educational efforts to ensure their safety as they work within Zone III regions will be referred to henceforth as Level One MR Personnel. Level Two MR Personnel-those who have been more extensively trained and intensively educated in the broader aspects of MR safety issues including, for example, issues related to the potential for thermal loading/ burns, direct neuromuscular excitation from rapidly changing gradients, etc., shall be referred to henceforth as Level Two MR Personnel (Beam et al., 2019). It is the

responsibility of the MR Medical Director of the site not only to identify the necessary training, but also to identify those individuals that qualify as Level Two MR Personnel. It is understood that the Medical Director of the MR site will be one whose education and experience in MR safety qualifies them for designation as Level Two MR Personnel (Crisp & Dawdy, 2018). Only MR Personnel should have free access to zones III and IV. All those not having successfully complied with these MR safety instruction guidelines shall be referred to henceforth as Non–MR Personne (Baker et al., 2024).

6.2.3. Patient and non-MR personnel screening

All non-MR personnel wishing to enter Zone III must first pass an MR safety screening process. Only MR personnel are authorized to perform an MR safety screen before permitting non-MR personnel into Zone III (Watson et al., 2020). The screening process and screening forms for patients, non-MR personnel, and MR personnel should be essentially identical. Specifically, one should assume that screened non-MR personnel, health care practitioners, or MR personnel may enter the bore of the MR imager during the MR imaging process (Al-Dayeh et al., 2020). All patients/Non–MR Personnel with a history of a potential ferromagnetic foreign object penetration must undergo further investigation prior to being permitted entrance to Zone III of the MR site. Examples of acceptable methods of screening include patient history, plain x-ray films, prior CT or MR of the questioned anatomic area, or access to written documentation as to the type of implant or foreign object that might be present (Kanal, 2020). Once positive identification has been made as to the type of implant/foreign object that is within a patient, best-effort assessments should be made to attempt to identify the MR compatibility or MR safety of the implant/object (Al-Dayeh et al., 2020).

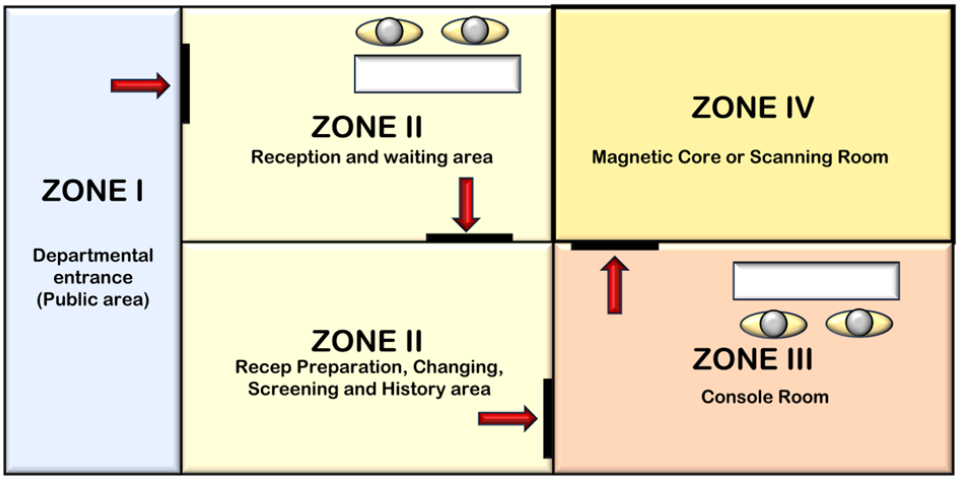

Figure 3: Schematic representation of the ACR 4-Zones of MRI

7. INFECTION EXPOSURE IN THE HOSPITAL

The six primary pathways for transmission, the first route is direct interaction. It follows that an infected individual needs to come into close contact with the host and organisms that are present in the sensitive tissue (van Seventer & Hochberg, 2017). For instance, syphilis and HIV infections can transfer directly into the mucous membrane of an infected individual if an infectious organism is present in the mucous membrane of the human (Peeling et al., 2017). The remaining five primary routes of transmission are indirect and comprise droplets, vehicles, airborne media, vehicles carrying vectors, and fluids. A fomite is an item harbouring a harmful organism (Anisuzzaman et al., 2023). Urine-contaminated catheters are a common example. The x-ray table, Bucky vertical, image receptors, sponsor positioning with pathogenic fluids, and possibly gloves are also included (Hariati et al., 2019). Arthropods known as vectors are organisms that, before becoming a new host, develop or multiply an infectious organism. Patients with such infections have the potential to infect others (Baxter et al., 2017). Among the vectors are insects that transmit Lyrne or Rocky Mountain disease, fleas carrying the dengue or malaria virus, and spotted fever. Every vehicle that contains microbes is a media. For instance, tainted blood, food, water, or medications (Socha et al., 2022). Five microns of dust or droplets evaporated by a long-suspended airborne air-borne microbe or a smaller spore contaminate the airborne air. These particles are inhaled by a susceptible host and air currents. To prevent the spread of these contaminated particles via the air, special ventilation, and air handling are required. Varicella, rubeola, and tuberculosis are among the airborne illnesses. These viruses can also be acquired by varicella by contact with vesicles (Gralton et al., 2011). The most common ways that gout is spread are through coughing, sneezing, talking, or singing. Contact between susceptible individuals' big eye droplets, and nasal, and oral germs with mucosal membranes results in droplet transmission. Unusual length, three feet or less, not hung in the air. Meningitis, pertussis, diphtheria, influenza, and the spread of pulmonary gout are a few examples (Dhand & Li, 2020). Bacterial spore-forming organisms are responsible for rare but deadly diseases such as

botulism, anthrax, and tetanus. Healthcare workers should wear gloves and masks, wash their hands before and after procedures, and make sure the table and other equipment should be clean afterward to reduce the risk of infection (Sasahara et al., 2016).

8. DISCUSSION

This review focuses on the safety in the Department of Radiology. Radiation is very harmful and can cause cancer by mutation in DNA (Linet et al., 2012). ALARA principle was developed to ensure that all steps to reduce radiation exposure are taken. Some programs for radiographers and technical staff should be organized in the department to increase the knowledge of radiographers and technical staff (Do, 2016; Frane & Bitterman, 2024). (101)Ways of radiation protection by reducing time, maintaining appropriate distance, and use of proper shielding should be followed by radiographer as well as doctor if they are working in intervention or fluoroscopy room (Mitchell & Furey, 2011). The dose limits should not be more than the ICRP recommended dose limits and records of radiation report of workers is managed by RSO (Nassef & Kinsara, 2017). ACR recommended MR Zones layouts should be followed to minimize the risks of accidents. MR personnel is appointed by head of the department or centre, who has enough knowledge and qualifications about MR safety (Hudson & Jones, 2019). Healthcare-associated infections, or nosocomial infections, are illnesses that can occur when a patient is in a medical facility. Following a surgical or medical operation, HAIs may develop. They could be little or fatal, and safety from infection is also important for workers (Haque et al., 2018).

9. CONCLUSION

We have discussed the effects of radiation on the body and their limits for the occupational worker and the public. So here safety is our concern there should be regular check-ups of the ray tube, there should be no leakage of radiation from the tube, and along with this x-ray room should be checked and the same is applied to the CT room. Occupational workers who are working in direct contact with exposure (fluoroscopic procedures) should wear a lead apron and Thermoluminescent dosimeters (TLD) badge to check their absorption dose after a regular period. Radiation used in both diagnosis and treatment in the field of health is an indispensable element. Health workers working in these radiation areas are exposed to low doses of radiation. Radiation exposure can cause various health problems in healthcare workers who experience this exposure. To avoid these health problems or to experience fewer health problems, health workers working in these units should apply all kinds of protection methods. These prevention methods should be evaluated both individually and in terms of the patient. In addition, other health professionals should make use of the radiation environment, which is an indispensable element in health, as little as possible. Exposure to radiation during diagnosis or treatment may cause delays in the healing process. All modalities like X-ray, CT-Scan, and MRI infrastructure should be divided into different zones according to standard safety rules example- MRI infrastructure is divided into four zones. Zone I is for the general public area, and Zone II is for the patient history and preparation area. Zone III should be physically restricted from the general public only MR personnel will have free access. Zone IV MR Scanner room itself. We should use aseptic medical systems as a means of reducing and interfering with the process of spreading pathogenic microorganisms to the environment by using gloves, masks, and sanitizer, not using the same syringe for multiple patients, explaining to the patient about the procedure this thing reducing the chance of repetition.

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